KURAM VE UYGULAMADA EĞİTİM BİLİMLERİ EDUCATIONAL SCIENCES: THEORY & PRACTICE

Received: January 20, 2016
Revision received: July 7, 2016
Accepted: October 26, 2016
OnlineFirst: February 10, 2017

www.estp.com.tr
DOI 10.12738/estp.2017.2.0051 • April 2017 • 17(2) • 515–528

Research Article

An Investigation of the Factor Structure of the Torrance Tests of Creative Thinking*

William M. Bart[1]
University of Minnesota

Brad Hokanson[2]
University of Minnesota

Iclal Can[3, 4]
Middle East Technical University Northern Cyprus Campus

Abstract

This study investigated the factorial structure of the Torrance Tests of Creative Thinking (TTCT) Figural Form A with an aim to find out whether the two-factor structure of creative thinking established by Kim and Kim, Cramond, and Bandalos holds true for the older participants. Data were gathered from 996 8th grade students and 748 11th grade students from a suburban public school system in Minnesota. Based on previous research and Kirton's Adaption-Innovation (KAI) theory, one and two-factor models were tested in the study. Upon checking the related assumptions, confirmatory factor analyses with Maximum Likelihood (ML) estimation were conducted using LISREL 8.71. The results indicated that a two-factor model established by Kim and her colleagues was a better fit than a one-factor model. This shows that fluency and originality load onto the latent variable termed the innovative factor, elaboration and abstractness of titles load onto the latent variable termed the adaptive factor, and resistance to premature closure loads on both latent variables. Our results suggest that any efforts to assess and promote creativity should take into consideration the two domains of creativity posited in KAI theory.

Keywords

TTCT • Creative thinking • Creativity • Factorial structure • Adaption-Innovation theory

* This research was supported in part by a grant from the Metropolitan Research Grant Program of the University Metropolitan Consortium and the University of Minnesota Center for Urban and Regional Affairs. The authors express thanks to the School District personnel, who helped in the implementation of the research and in the collection of the data.

1 **Correspondence to:** William M. Bart (PhD), Department of Educational Psychology, University of Minnesota; 162 Education Sciences Building, 56 East River Road, Minneapolis, MN 55113, USA. Email: bartx001@umn.edu

2 Department of Design, Housing, and Apparel, University of Minnesota; 32 McNeal Hall, 1985 Buford Ave., St. Paul, MN 55108-6136. Email: brad@umn.edu

3 Guidance and Psychological Counseling Program, Middle East Technical University Northern Cyprus Campus; Academic Buildings, R-138, Middle East Technical University Northern Cyprus Campus, 99738 Kalkanlı, Güzelyurt, Mersin 10, Turkey. Email: iclal@metu.edu.tr

4 Previously Iclal Sahin

Citation: Bart, W. M., Hokanson, B., & Can, I. (2017). An investigation of the factor structure of the Torrance Tests of Creative Thinking. *Educational Sciences: Theory & Practice*, *17*, 515–528. http://dx.doi.org/10.12738/estp.2017.2.0051

Measuring creative thinking abilities of individuals is an increasingly important area in education. The Torrance Tests of Creative Thinking (TTCT) are "the most commonly used test of divergent thinking" to serve this purpose (Plucker & Renzulli, 1999, p. 39). Devised by Torrance and his colleagues (Torrance, 2008), the TTCT has more than 35 language translations available (Millar, 2002) and are "still enormously popular" (Runco & Acar, 2012, p. 67). The TTCT has attracted the attention of many researchers investigating its psychometric features and focusing on the structure of creativity (e.g., Clapham, 1998; Heausler & Thompson, 1988; Hocevar, 1979; Kim, 2006a; Kim, Cramond, & Bandalos, 2006). However, the latent structure of creativity is still controversial. Although some researchers argue that creativity is uni-dimensional, some other researchers suggest that it has more than a single factor structure. This research served as an investigation of whether the two-factor structure established by Kim (2006a) and Kim et al. (2006) holds true for seemingly two new population groups: 8th and 11th graders.

Being "the most widely used divergent thinking tests" (Clapham, 2004, p. 829), the major purpose of the TTCT was to individualize instruction (Torrance, 1966, 1974). However, it is mostly used to identify gifted children (Kim, 2006b), although it is also used for research and instructional planning (Kim, 2006b). The TTCT is originally "based in part on Guilford's Structure of Intellect model" (Krumm, Lemos, & Filippetti, 2014, p. 72). Four dimensions of the TTCT, namely, fluency, originality, elaboration, and flexibility, were adopted from Guilford's divergent thinking factors (Kim, 2006a). Although the TTCT is based on Guilford's model, it also differs from Guilford's test batteries as "Guilford's test tasks attempt to elicit as factorially pure mental functioning as possible" (Torrance, 2008, p.47). In addition, it differs from the test battery of Wallach and Kogan as "the Wallach and Kogan activities all attempt to elicit associations" (Torrance, 2008, p. 47).

The TTCT has six versions. After being published in 1966, it was re-normed in 1974, 1984, 1990, 1998, and 2008. The re-norming process affected the scoring procedures. However, the content of the TTCT did not go through any alteration (Kim, 2006a, 2006b, 2011). The earliest two versions of the TTCT assessed fluency, originality, elaboration, and flexibility.

In the 1984 version of the TTCT, flexibility was excluded from the analyses; whereas, abstractness of titles and resistance to premature closure were included in the TTCT (Hébert, Cramond, Neumeister, Millar, & Silvian, 2002; Torrance & Ball, 1984). The reason why Torrance excluded flexibility from the analysis was that there was high correlation between fluency and flexibility (Hébert et al., 2002). A new measure termed creative strengths was included in the scoring in 1984 as well. This measure included thirteen criterion-referenced measures (indicators).

The TTCT battery has two different forms: the TTCT Figural and Verbal, each having two parallel forms (Torrance, 1974, 1990, 1998, 2008). "With both measures, the instructions are designed to motivate the respondents to give unusual, detailed responses" (Cramond, Matthews-Morgan, Bandalos, & Zuo, 2005, p. 284). The Figural TTCT has a wide range of application ranging from measuring creative thinking skills among young children to identifying creative adults. It includes three picture-based activities: picture construction, picture completion, and repeated figures of lines or circles. This test lasts 30 minutes with each activity being allocated 10 minutes (Torrance, 1990, 1998, 2008).

Conceptual Framework

Many researchers have studied the structure of creativity using the TTCT (e.g., Clapham, 1998; Heausler & Thompson, 1988; Hocevar, 1979; Kim, 2006a; Kim et al., 2006; Krumm et al., 2014). Many studies were also conducted using other tests of creative thinking or test batteries from different creative thinking tests (e.g., Bachelor, 1986-1987; Michael & Bachelor, 1990; Richardson, 1986; Runco & Mraz, 1992). These studies have raised questions about the dimensionality of creativity.

Several researchers have contended that creativity is uni-dimensional and that it has a single factor structure (e.g., Clapham, 1998; Heausler & Thompson, 1988; Hocevar, 1979; Runco & Mraz, 1992). For example, Clapham (1998) investigated the structure of TTCT Figural forms A and B among 334 university students. The principal component analyses revealed that there was one general factor.

Similarly, Heausler and Thompson (1988) collected data from 69 kindergarten and 63 second graders using the TTCT Figural form A. Their results suggested a general creativity factor, too. In their study, Heausler and Thompson (1988) wrote that "A fundamental problem with the derivation of the five separate scores is that the scores are derived from the same response data; this introduces potentially spuriously high subscale correlation" (p. 466), suggesting that the TTCT has one single factor structure. However, Torrance (1974), himself, suggests that use of a composite score should be avoided as each subscale in the TTCT measures a different area although a composite score "provided a good measure of an individual's creative energy" (Torrance, as cited in Cramond et al., 2005, p. 284).

Many researchers have not accepted the idea that creativity is uni-dimensional. Kim (2006a) argues that "Because Guilford (1959; 1962) viewed divergent thinking as multidimensional, many researchers have come to the conclusion that creativity consists of several psychological factors" (p. 252). The idea that creativity is not uni-dimensional is also evident in Kirton's Adaption-Innovation (KAI) theory (1976) in which he introduced two cognitive styles to creative thinking, namely, adaptive and

innovative. Kirton (1976) introduced the view that creative thinking is a continuum ranging from being adaptive to being innovative, and individuals may be classified as adaptors or as innovators in terms of their preferred approaches to solving problems. An individual is adaptive to the extent to which the individual prefers to engage in activities in a better way. An individual is innovative to the extent to which the individual prefers to engage in activities differently. Kirton (1976) posits that "... the more the structure surrounding a problem is incorporated within and treated as part of the problem, the more any solution is likely to be radical and innovative (i.e., "doing things differently"). The less structure is challenged, the more any solution is likely to be adaptive (i.e., "doing things better")" (p. 622). Kirton (1976) developed an inventory to locate the individuals on the adaptor and innovator continuum. Kirton's Adaption-Innovation (KAI) theory has informed subsequent research on creative thinking (e.g., Kim, 2006a; Kim et al., 2006; Krumm et al., 2014).

Kim (2006a) analyzed creative thinking test score data from a sample of approximately 500 6th grade students. The test whose data she analyzed was data for the TTCT - Figural Form A. Using confirmatory factor analysis (CFA), Kim (2006a) determined that the best-fitting model was a two-factor model compatible with Kirton's theory of cognitive styles to creativity. That model hypothesized that the fluency and originality subscales loaded onto a factor that she termed the "innovative" factor, that the elaboration and abstractness of titles subscales loaded onto a factor that she termed the "adaptive" factor, and that the resistance to premature closure subscale loaded on both factors.

Kim (2006a) offered the following statement as the basis for that third aspect of her hypothesized two-factor model: "The double loading by resistance to premature closure is consistent with Torrance's (1984; 1990; 1998) theory that creative people would be able to keep their mind open long enough to make mental leaps, whereas less creative individuals tend to prematurely leap to conclusions." (p. 253). The two-factor model without the creative strengths subscale being included provided a better fit than the two-factor model with the creative strengths subscale being included. That result led Kim (2006a) to infer that the creative strengths subscale loads on a separate third factor.

In another study conducted by Kim et al. (2006) based on KAI theory, TTCT-Figural data from 1,000 kindergarten students, 1,000 third graders, and 1,000 sixth graders were analyzed to test the factorial structure of the TTCT. Similar to what Kim (2006a) found with 6th graders, the results revealed a two-factor solution for the TTCT, fluency and originality loading on an innovative factor and elaboration and abstractness of titles loading on an adaptive factor. Resistance to premature closure had a double loading on both factors.

In a recent study, Krumm et al. (2014) used CFA to test four theoretical models regarding the factorial structure of creativity. They used Figural form B data collected from 577 Spanish-speaking children (331 girls and 246 boys) between 9 and 14 years of age in Argentina. Krumm et al. (2014) found the existence of two general factors, innovative and adaptive. Similarly, the CFA revealed that the model that best fit the data was the one without creative strengths in which fluency and originality loaded on the innovative factor and elaboration and abstractness of titles loaded on the adaptive factor. However, the findings of Krumm et al.'s study were not entirely consistent with the findings of Kim (2006a) and Kim et al. (2006), as Krumm et al.'s (2014) study indicated that resistance to premature closure did not load on the innovative factor, but only on the adaptive factor.

Overall, these studies highlight the need for investigating the factorial structure of the TTCT in new population groups as the populations are changing and thus earlier results may not apply to contemporary samples. The major purpose of this study is to investigate the factor structure of creative thinking as measured by the TTCT with the goal being to determine if the two-factor structure established by Kim (2006a) and Kim et al. (2006) holds true for two completely different population groups (8th and 11th graders). Apart from this, as the status of premature closure seems unresolved in previous studies, we believe that our study will provide new insights on the role of premature closure in the structure of creativity as assessed by the TTCT in older participants. The research question is as follows: Does the two-factor structure of creative thinking as established by Kim (2006a) and Kim et al. (2006) hold true for 8th and 11th graders?

As a replication of the studies reported by Kim (2006a) and Kim et al. (2006), the present study proposes a two-factor model for the latent structure of the TTCT. Figure 1 depicts the two-factor model for both grades. As demonstrated in the hypothesized model, fluency and originality load onto the latent variable termed the innovative factor; while, elaboration and abstractness of titles load onto the latent variable termed the adaptive factor. The hypothesized model further proposes that resistance to premature closure loads on both latent variables.

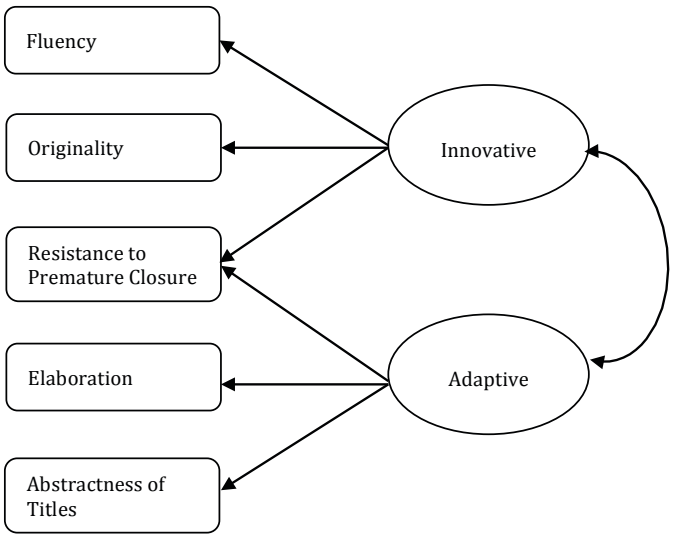

Figure 1. Hypothesized two-factor model in the study.

Method

This study was conducted as part of a comprehensive project on creativity and scholastic achievement in 8th and 11th graders, and funded by the University of Minnesota. Using the same data, in a previous study, we explored the gender differences among student creative thinking skills (Bart, Hokanson, & Sahin, 2015). In the present study, however, we focused on the factorial structure of the TTCT and primarily tested the tenability of the two-factor structure offered by Kim (2006a) and Kim et al. (2006). We primarily aimed to find out if the two-factor structure would appear in the same form among 8th and 11th graders.

Participants

996 8th graders (503 boys and 493 girls) and 748 11th graders (407 boys and 341 girls) from a suburban public school district in Minnesota participated in the study. The 8th graders had a M_{age} = 14.11 years with SD_{age} = .34 years and the 11th graders had a M_{age} = 17.32 years with SD_{age} = .35 years. Descriptive information for boys and girls separately can be found in our previous study (Bart et al., 2015).

Instrument

The instrument used to assess creative thinking is the Torrance Tests of Creative Thinking (TTCT), Figural Form A. "The figural form, especially, has equity benefits in terms of gender and race and for persons who have various language, socioeconomic status, and cultural backgrounds" (Cramond; Torrance, as cited in Kim, 2006a, p.

251). With regard to the reliability of the TTCT, Kuder-Richardson 21 "reliability coefficients involving the creativity index are centered at .90 for the various grades, and at .89 for various ages. Coefficients for the average standard score, primarily an intermediate measure involved in developing the creativity index, are only slightly lower" (Torrance, 2008, p. 44).

With regard to the inter-rater reliability of the TTCT, the results of five rater-reliability studies conducted with 2nd, 5th, and 8th graders as well as college level students and a random group of students ranged between .90 and .99 for five subscales except the college level student group which had a coefficient of .78 for the resistance to premature closure subscale (Torrance, 2008). As for the validity of the TTCT, the test has relatively strong predictive validity as can be seen in Torrance's follow up study which was conducted 40 years after the TTCT was first administered to the participants (Cramond et al., 2005).

The Figural TTCT provides norm-referenced scores for five subtests: fluency ("the total number of relevant responses"), originality ("the statistical infrequency and unusualness of the response"), abstractness of titles ("the subject's synthesizing and organizing processes of thinking"), elaboration ("the imagination and exposition of detail"), and resistance to premature closure ("ability to keep open and delay closure long enough to make the mental leap that makes possible original ideas") (Torrance, 2008, p. 39). The TTCT also provides criterion-referenced scores for the creative strengths subscale, scores that were not included in our analyses for the present study. The participants in this study completed the TCTT-Figural, Form A with five creative thinking subtest scores being recorded for each participant.

Procedure

The researchers worked in collaboration with the cooperating school district during the data collection process. The district office used a purposive sampling method in the selection of participants so that the sample of participants would reflect the diversity of the school district student population in terms of social class, ethnic group, and gender. After receiving human subjects board review approval for the study, the parents were notified that the district office collected the data for research purposes. Upon receiving parental assent, the teachers who were trained by one of the researchers administered the data collection tools: TTCT and the general demographic questionnaire to the students in groups. The test responses of the students were sent to the publisher of the TTCT for scoring. After the scoring process, the district office matched the student creativity scores with student information, and deleted personal data to ensure the confidentiality of the data.

Data Analysis

The raw subscale scores were used in this study as the use of the standard scores produced quite similar results. Table 1 presents the means and standard deviation scores of the creativity subscales for the 8th and 11th grade students.

Table 1
Descriptive Statistics

Subscale	Grade	M	SD
Fluency	8th	24.02	9.41
	11th	20.73	9.19
Originality	8th	16.66	7.03
	11th	14.82	6.94
Elaboration	8th	7.75	2.72
	11th	7.16	2.46
Abstractness of Titles	8th	6.18	4.02
	11th	6.31	3.95
Resistance to Premature Closure	8th	13.41	4.02
	11th	12.89	4.33

Data analysis was conducted in two successive steps: (a) preliminary analyses and (b) confirmatory factor analyses. Preliminary analyses entailed conducting missing data analysis, screening for outliers, and checking univariate and multivariate normality, as maximum likelihood (ML) estimation assumes adequate sample size and univariate and multivariate normality (Brown, 2006). These assumptions were tested using SPSS 20.

First of all, the data were screened for missing data, and no missing data was identified. Next, the univariate outliers were detected through the stem-and-leaf plots and box plots (Parke, 2013) of SPSS. The stem and leaf plots were used to calculate the extreme values that will be used to mark outliers in each subscale data and the boxplots were used to detect the outliers that have these extreme values with their case numbers. The outliers detected in this way were eliminated from the data sets as even a small number of outliers in a large data can affect statistical results for a data set (Thompson, 2004). The skewness and kurtosis values for each creativity subscale were assessed and they were all close to zero for the 8th and 11th grades data. This indicated that the univariate normality assumption was met. To test multivariate normality, Mahalanobis distance (D^2) for each individual in the data sets was calculated (Thompson, 2004), and no value in the probability distribution of Mahalanobis distance exceeded .0001. Thus, no multivariate outliers were detected.

Results

Confirmatory factor analyses with ML estimation were performed using LISREL 8.71 (Jöreskog & Sörbom, 2004) to test the fit of the one-factor and two-factor models for the factor structure of the TTCT. Consistent with the preliminary studies of Kim

(2006a) and Kim et al. (2006) and with Kirton's theory of two cognitive styles to creativity, confirmatory factor analyses with two-factors were conducted with five observed indicators. In the hypothesized two-factor model, two indicators, fluency and originality, load onto the latent variable termed the innovative factor; two other indicators, elaboration and abstractness of titles load onto the latent variable termed the adaptive factor, and the last indicator, resistance to premature closure, loads on both latent variables. Confirmatory factor analysis with one factor was also performed based on the previous findings suggesting that creativity is uni-dimensional (e.g., Clapham, 1998; Hocevar, 1979). Apart from this, with an aim to resolve the status of premature closure in the previous studies (e.g., Krumm et al. 2014), confirmatory factor analyses with two-factors in which premature closure loading onto either on adaptive or innovative latent variable were also conducted. To enable the readers to compare the findings of the present study with those of Kim (2006a) and Kim et al. (2006), the results, tables, and figures were presented in a similar fashion with these two studies.

Table 2 presents the results of Pearson product-moment correlation coefficients between the variables. The correlation coefficients between the subscales of creativity were significant with $p < .01$. The highest correlation was between originality and fluency for both grades (8^{th} grades = .78; 11^{th} grades = .79).

Table 2
Correlations between Creativity Subscales for 8^{th} and 11^{th} Grades

Subscale	Grade	Fluency	Originality	Elaboration	Abstractness of Titles	Resistance to Premature Closure
Fluency	8^{th}					
	11^{th}	-				
Originality	8^{th}	.78**				
	11^{th}	.79**	-			
Elaboration	8^{th}	.31**	.42**			
	11^{th}	.34**	.44**	-		
Abstractness of Titles	8^{th}	.09**	.22**	.44**		
	11^{th}	.15**	.21**	.44**	-	
Resistance to Premature Closure	8^{th}	.42**	.39**	.31**	.29**	
	11^{th}	.50**	.43**	.29**	.31**	-

** $p < .01$.

The model fit was assessed based on the two-index strategy of Hu and Bentler (1999). In order to discriminate good models from poor ones, Hu and Bentler (1999) suggest using the ML-based standardized root mean square residual (SRMR) and supporting it with an index such as the incremental fit index (IFI), the comparative fit index (CFI), the non-normed fit index (NNFI), and the root mean square error of approximation (RMSEA). For this purpose, the goodness of fit was evaluated using root SRMR, IFI, CFI, NNFI, and RMSEA using the cut off scores of SRMR (≤ 0.8), IFI ($\geq .95$), CFI ($\geq .95$), NNFI ($\geq .95$), and RMSEA ($\leq .06$), as suggested by Hu and Bentler (1999). We used SRMR as the major index and supplemented it with IFI and CFI.

The chi-square difference between the one-factor and two-factor models was also evaluated. The chi-square differences between the one-factor model and two-factor model with premature closure loading onto both latent variables were significant for both 8th and 11th grades. This indicated that the two-factor model hypothesized in the present study fit the data better than the one-factor model (See Table 3). In addition, the goodness-of-fit indices except for NNFI and RMSEA were within the cut-off values for both the 8th grade ($\chi^2(3) = 76.03$, SRMR = .04, IFI = .95, CFI = .95, NNFI = .82, RMSEA = .16) and the 11th grade ($\chi^2(3) = 69.84$, SRMR = .04, IFI = .95, CFI = .95, NNFI = .82, RMSEA = .18). As Table 3 indicates, SRMR is supplemented by two incremental fit indices (IFI and CFI). This shows that the 8th and 11th grade data fit the two-factor model hypothesized in the study, but the one-factor model failed to fit the 8th and 11th grade data, as all model fit indices indicated poor fit.

As for the two-factor models with resistance to premature closure loading onto either adaptive or innovative factor, resistance to premature closure loading onto innovative factor did not converge in both 8th and 11th grade data. In addition, resistance to premature closure loading onto adaptive factor did not converge in 11th grade data while it converged in 8th grade data. As Table 3 shows, the chi-square differences between (a) the one-factor model and the two-factor model with premature closure loading onto adaptive factor and (b) the two-factor model hypothesized in the study and two-factor model with premature closure loading onto adaptive factor in 8th grade data were significant. Although the chi-square differences may indicate that two-factor model in which premature closure loading onto adaptive factor seemed to fit the 8th grade data better than the one-factor model, it failed to fit the 8th grade data when compared to the two-factor model hypothesized in the present study. This is further supported by all goodness-of-fit indices except for SRMR, which were not within the cut-off values for the 8th grade data.

Thus, the results suggest that the two-factor model hypothesized in the study fits both 8th and 11th grade data and that fluency and originality loaded on the latent variable termed the innovative factor and elaboration and abstractness of titles loaded on the latent variable termed the adaptive factor. The results also indicate that resistance to premature closure loaded on both latent variables.

Parameter estimates were also investigated to examine the two-factor model hypothesized in the study. The parameter estimates indicated that the indicators were highly related to their latent variables (range of R^2 = .68 to .90 for 8th grades and R^2 = .69 to .79 for 11th grades), except for abstractness of titles and resistance to premature closure, which had low R^2 values (R^2 = .28 and .23 for the 8th grade students and R^2 = .28 and .29 for the 11th grade students respectively). These values suggest that fluency, originality, and elaboration are better indicators of their latent factors than abstractness of titles and resistance to premature closure, which had low R^2 values.

Table 3
Results of Model Comparison with One and Two Factors

Grades	Number of Factors	c^2	*df*	NNFI	IFI	CFI	*RMSEA*	*SRMR*	$\Delta\chi^2$
8	One	264.82	5	.66	.83	.83	.24	.11	
	Two[a]	121.743	4	.81	.92	.92	.178	.074	143.077[c]**
	Two[b]	76.03	3	.82	.95	.95	.16	.04	188.79[c]** 45.713[d]**
11	One	188.53	5	.70	.85	.85	.23	.10	
	Two	69.84	3	.82	.95	.95	.18	.04	118.69[c]**

Note. NNFI = Non-normed fit index; IFI = incremental fit index; CFI = comparative fit index; RMSEA = root mean square error of approximation; SRMR = standardized root mean square residual

[a] Two-factor model with resistance to premature closure loading onto adaptive factor

[b] Two-factor model with resistance to premature closure loading onto both factors (hypothesized model)

[c] Comparison to one-factor model

[d] Comparison to two-factor model with resistance to premature closure loading onto adaptive factor

** $p < .01$.

Discussion

This study offers support for the idea that creativity is two-dimensional and contributes to our understanding of the latent structure of creativity as assessed by the TTCT, suggesting that the two-factor structure exists in the same structure from elementary to high school. Although the results of the present study differ from some published studies which suggest that creativity is uni-dimensional (e.g., Clapham, 1998; Heausler & Thompson, 1988; Hocevar, 1979; Runco & Mraz, 1992), they are consistent with those of Kim (2006a) and Kim et al. (2006), who obtained a two-factor solution for creativity as measured by the TTCT. In accordance with the present results, Kim (2006a) and Kim et al. (2006) specified a two-factor model in which fluency and originality loaded on an innovative factor, elaboration and abstractness of titles loaded on an adaptive factor, and resistance to premature closure loaded on both factors.

The present findings seem to be consistent with Krumm et al.'s (2014) research, which found that creativity as assessed by the TTCT had a two-factor structure (innovative and adaptive). However, the results of the present study also differ from those reported by Krumm et al. (2014), as the present findings indicated that resistance to premature closure loads onto both factors; whereas, Krumm et al (2014) found that only the adaptive factor is loaded by resistance to premature closure. This study also contributes to our understanding of creativity by providing evidence that there is a high correlation between fluency and originality. This finding is in agreement with what Chase (1985), Dixon (1979), Heausler and Thompson (1988), Kim (2006a), and Kim et al., (2006) found. Torrance himself reported a high correlation among these

subscales. Although the high correlation between fluency and originality is considered an indication of uni-dimensionality by some researchers (e.g., Chase, 1985; Heausler & Thompson, 1988), it seems that these two measures assess two different abilities and should be interpreted accordingly as two major indices of the innovative factor.

This study has some limitations. First, creativity subscale scores of the 8th and 11th graders in a large public school district in Minnesota were used in the study. As a result, this study may not reflect the structure of the TTCT in all grade levels or similar grades in different educational contexts. Secondly, R^2 values pertaining to the abstractness of titles and resistance to premature closure in both the 8th and 11th grade data indicated that they are weak indicators of the adaptive factor on which they load compared to fluency, originality, and elaboration. Thus, the results pertaining to these subscales should be interpreted accordingly. Next, some extraneous variables like student motivation (Torrance, 1974) may have affected student responses to the test items. Apart from the aforementioned limitations of the study, one should also note that the scoring of the TTCT could be regarded as a limitation as well as "Reliable and valid scoring requires extensive experience" and "This frequently necessitates expensive and time-consuming professional scoring" (Clapham, 2004, p. 829).

In conclusion, this study suggests that any efforts to assess and promote creativity should take into consideration two domains of creativity, that is, adaption and innovation, to obtain a realistic assessment and effective promotion of creative thinking abilities of individuals. Our results further suggest that two-factor structure hypothesized in the study may be incorporated into TTCT's scoring and norms.

References

Bachelor, P. (1986-1987). Higher-order factors in Guilford's SOI model: Divergent productions. *Educational Research Quarterly, 11*(2), 29–40.

Bart, W. M., Hokanson, B., & Sahin, I. (2015). An investigation of the gender differences in creative thinking abilities among 8th and 11th grade students. *Thinking Skills and Creativity, 17,* 17–24. http://dx.doi.org/10.1016/j.tsc.2015.03.003

Brown, T. A. (2006). *Confirmatory factor analysis for applied research*. New York, NY: Guilford Press.

Chase, C. I. (1985). Review of the Torrance Tests of Creative Thinking. In J. V. Mitchell, Jr. (Ed.), *The ninth mental measurements yearbook* (pp. 1631–1632). Lincoln, NE: University of Nebraska, Buros Institute of Mental Measurements.

Clapham, M. M. (1998). Structure of Figural Forms A and B of the Torrance Tests of Creative Thinking. *Educational & Psychological Measurement, 58,* 275–283. http://dx.doi.org/10.1177/0013164498058002010

Clapham, M. M. (2004). The convergent validity of the Torrance Tests of Creative Thinking and creativity interest inventories. *Educational & Psychological Measurement, 64,* 828–841. http://dx.doi.org/10.1177/0013164404263883

Cramond, B., Matthews-Morgan, J., Bandalos, D., & Zuo, L. (2005). A report on the 40-year follow-up of the Torrance tests of creative thinking: Alive and well in the new millennium. *Gifted Child Quarterly, 49,* 283–291. http://dx.doi.org/10.1080/10400419.2011.627805

Dixon, J. (1979). Quality versus quantity: The need to control for the fluency factor in originality scores from the Torrance tests. *Journal for the Education of the Gifted, 2,* 70–79.

Heausler, N. L., & Thompson, B. (1988). Structure of the Torrance Tests of Creative Thinking. *Educational and Psychological Measurement, 48,* 463–468. http://dx.doi.org/10.1177/0013164488482021

Hébert, T. P., Cramond, B., Neumeister, K. L. S., Millar, G., & Silvian, A. F. (2002). *E. Paul Torrance: His life, accomplishments, and legacy.* Storrs: The University of Connecticut, The National Research Center on the Gifted and Talented (NRC/GT).

Hocevar, D. (1979). The unidimensional nature of creative thinking in fifth grade children. *Child Study Journal, 9,* 273–278.

Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indices in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling, 6,* 1–55. http://dx.doi.org/10.1080/10705519909540118

Jöreskog, K. G., & Sörbom, D. (2004). *LISREL 8.71 for Windows* [Computer software]. Lincolnwood, IL: Scientific Software International, Inc.

Kim, K. H. (2006a). Is creativity unidimensional or multidimensional? Analyses of the Torrance Tests of Creative Thinking. *Creativity Research Journal, 18,* 251–259. http://dx.doi.org/10.1207/s15326934crj1803_2

Kim, K. H. (2006b). Can we trust creativity tests? A review of the Torrance Tests of Creative Thinking (TTCT). *Creativity Research Journal*, *18*, 3–14. http://dx.doi.org/10.1207/s15326934crj1801_2

Kim, K. H., Cramond, B., & Bandalos, D. L. (2006). The latent structure and measurement invariance of scores on the Torrance Tests of Creative Thinking-Figural. *Educational and Psychological Measurement*, *66*, 459–477. http://dx.doi.org/10.1177/0013164405282456

Kim, K. H. (2011). The creativity crisis: The decrease in creative thinking scores on the Torrance Tests of Creative Thinking. *Creativity Research Journal, 23*, 285–295. http://dx.doi.org/10.1080/10400419.2011.627805

Kirton, M. J. (1976). Adaptors and innovators: A description and measure. *Journal of Applied Psychology, 61,* 622–629.

Krumm, G., Lemos, V., & Filippetti, V. A. (2014). Factor structure of the Torrance tests of creative thinking figural Form B in Spanish-speaking children: Measurement invariance across gender. *Creativity Research Journal*, *26*, 72–81. http://dx.doi.org/10.1080/10400419.2013.843908

Michael, W. B., & Bachelor, P. (1990). Higher-order structure-of-intellect creativity factors in divergent production tests: A re-analysis of a Guilford data base. *Creativity Research Journal*, *3*, 58–74. http://dx.doi.org/10.1080/10400419009534333

Millar, G. W. (2002). *The Torrance kids at mid-life: Selected case studies of creative behavior.* Westport, CT: Ablex.

Parke, C. (2013). *Essential first steps to data analysis: Scenario-based examples using SPSS*. California, CA: Sage.

Plucker, J. A., & Renzulli, J. S. (1999). Psychometric approaches to the study of human creativity. In R. J. Sternberg (Ed.), *Handbook of creativity* (pp. 35–61). Cambridge, UK: Cambridge University Press.

Richardson, A. G. (1986). Two factors of creativity. *Perceptual and Motor Skills*, *63*, 379–384.

Runco, M. A., & Acar, S. (2012). Divergent thinking as an indicator of creative potential. *Creativity Research Journal, 24*, 66–75. http://dx.doi.org/10.1080/10400419.2012.652929

Runco, M. A., & Mraz, W. (1992). Scoring divergent thinking tests using total ideational output and a creativity index. *Educational and Psychological Measurement, 52,* 213–221. http://dx.doi.org/10.1177/001316449205200126

Thompson, B. (2004). *Exploratory and confirmatory factor analysis: Understanding concepts and applications.* Washington, DC: American Psychological Association.

Torrance, E. P. (1966). *The Torrance tests of creative thinking: Norms-technical manual* (Research ed.). Princeton, NJ: Personnel Press.

Torrance, E. P. (1974). *The Torrance tests of creative thinking: Norms-technical manual* (Research ed.). Princeton, NJ: Personnel Press.

Torrance, E. P. (1990). *The Torrance tests of creative thinking: Norms-technical manual figural (streamlined) forms A & B*. Bensenville, IL: Scholastic Testing Service.

Torrance, E. P. (1998). *The Torrance tests of creative thinking: Norms-technical manual figural (streamlined) forms A & B*. Bensenville, IL: Scholastic Testing Service.

Torrance, E. P. (2008). *The Torrance tests of creative thinking: Norms-technical manual figural (streamlined) forms A & B*. Bensenville, IL: Scholastic Testing Service.

Torrance, E. P., & Ball, O. E. (1984). *The Torrance tests of creative thinking: Streamlined scoring guide Figural A and B*. Bensenville, IL: Scholastic Testing Service.